Effect of Speech Recognition Testing on Self-Reported State Anxiety

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by

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Abstract

The effects of difficult listening tasks on state anxiety have not been tested in older populations. To determine if a relationship existed between difficult listening situations and state anxiety, self-reported state anxiety pre- and post-speech recognition testing was measured in young and older adults. Three speech-in-noise tests and one dichotic listening test were utilized. Ten young adults with normal hearing and ten older adults with bilateral symmetric sensorineural hearing loss participated. Results revealed no significant difference in state anxiety as a function of group. One significant difference in self-reported state anxiety as a function of test condition was found: there was a significant increase in anxiety in the older adult group after the dichotic digits condition. Average self-reported state anxiety scores for both young and older adults were within normal ranges during and after speech recognition testing. Results revealed no correlation between speech recognition performance and state anxiety. In addition, speech recognition performance was as expected, with older adults performing poorer than the young adults. The results of the present study suggest that state anxiety was minimally affected by speech-in-noise testing and not likely a cause for concern during standard audiologic evaluations. In contrast, the significant increase in state anxiety related to dichotic testing experienced by older adults suggests that additional counseling and encouragement during dichotic testing may be beneficial to patient comfort.

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Chapter 1
Introduction and Literature Review

Introduction

There is substantial evidence reporting that hearing declines as age increases. Older adult listeners are more likely to report struggling to understand a spoken message in a noisy environment than younger listeners. Experimentally, studies have reported that older adult listeners often contend with peripheral hearing loss, auditory processing deficits, cognitive declines, and combinations of these conditions (Humes, 1996; Bellis & Wilber, 2001; Harris, Dubno, Keren, Ahlstrom, & Eckert, 2009; Humes et al., 2012). Listeners with hearing loss struggle to recognize an auditory signal. Listeners with auditory processing deficits struggle to interpret auditory signals. Also, listeners with cognitive declines struggle to understand and remember the auditory signal. These factors often interact to make communicating difficult for older listeners.

Anxiety is a potential consequence for older adults in difficult listening situations. Task difficulty and participant proficiency are directly related to levels of anxiety (Hembree, 1988). The harder a task is, and the less proficient a participant is at that task, the more anxiety-inducing that task will be. Older adults often perceive listening in environments compounded with background noise as a difficult task. Experimental speech recognition results also show that older adults exhibit reduced performance on auditory tasks, as compared to younger listeners (Roup, Wiley, & Wilson, 2006; Yilmaz, Sennaroglu, Sennaroglu, & Kose, 2007; Barrenas & Wikstrom, 2000). Due to this reduced proficiency and increased difficulty, listening in compounded environments may cause anxiety in older listeners.

Anxiety levels in older adults are correlated with self-esteem and self-reported quality of life in older adults (Weinstein & Ventry, 1982). The higher an older adult's anxiety levels, the lower their self-reported quality of life. The report by Weinstein and Ventry also reviewed issues concerning social isolation and depression in older adults. A low quality of life often causes an older adult to pull away from friends and family, efficiently socially isolating oneself. In addition, there is a high correlation between social isolation and depression in older adults.

To help older adults avoid social isolation and depression, it would be helpful to identify possible anxiety triggers in older adults. Based on anecdotal claims regarding stressful listening situations and poor speech recognition performance, difficult listening environments appear to be anxiety-inducing for older adults (Kramer, Kapteyn, & Festen, 1998; Yueh, Shapiro, MacLean, & Shekelle, 2003). It is important to determine if there is an association between difficult listening situations and anxiety in older adults. If an association is determined, further research will be necessary to determine how to reduce the anxiety so that it is less of an effect on an older person's quality of life.

Speech Recognition Testing

To evaluate a listener's ability to perceive a speech signal, clinicians often utilize a variety of unique assessments referred to as speech perception tests. Speech recognition tests make up one subset of speech perception testing. In a speech recognition task, a listener is presented with a speech signal that has been compounded in some way (background noise, competing speech signals, etc.). Even with these complications, the listener must focus on the desired signal and report it back to the examiner. Trying to hold a conversation with the television on or the radio playing in the background are examples of “real world” equivalents to these speech recognition tasks. In these daily settings, the listener must be aware that competing signals come from multiple sources, and the listener must focus on the desired signal while tuning out the undesirable information. Speech recognition tasks simulate a difficult real-world listening situation in a controlled setting.

Speech recognition tests are utilized for a variety of purposes. Clinically, speech perception tests allow a clinician to determine whether or not a patient can understand spoken messages and build a treatment plan based on the results. Speech recognition testing is also utilized in research. Speech perception tests can be utilized to determine the effects of difficult listening situations on state anxiety, which is the focus of this study.

For the present study, two specific types of speech discrimination tasks will be employed: dichotic listening and speech-recognition-in-noise.

Dichotic Listening

In everyday settings people listen diotically, receiving the same stimulus in both ears so that there is no auditory processing competition over the stimulus. Comparatively, dichotic listening is unusual in the sense that two distinct stimuli are presented simultaneously to each ear. This unique presentation yields poorer percent correct recognition scores compared to diotic presentations (Noffsinger, Martinez, & Wilson, 1994). A poorer recognition score reflects task difficulty. This effect is exaggerated in older listeners as they consistently generate poorer percent correct recognition scores than younger listeners. (Noffsinger, Martinez, & Andrews, 1996; Strouse, Wilson, & Brush, 2000a, 2000b). Another trend within dichotic listening is the tendency for performance on materials presented to the right ear to be better than materials presented to the left ear. This phenomenon is commonly regarded as a right ear advantage (REA) (Kimura, 1967).

The REA is the tendency for results garnered from the right ear to be better than the results garnered from the left ear. As many as 95% of right-handed subjects exhibit this tendency (Bryden, 1988). More variability was found within left-handed subjects, but due to the lesser frequency of left-handed persons, the majority of the population exhibits a REA (Wilson & Leigh, 1996). In one experiment by Wilson and Leigh (1996), the average of the subjects' right ear recognition scores was 9.9% better than the scores from the subjects' left ears. This effect is also exaggerated in older listeners, as older listeners exhibit larger interaural differences than younger listeners on dichotic listening tasks (Roup et al., 2006).

Research by Kimura (1961, 1967) proposed a theory to explain the observed REA phenomena. Studies on brain localization have shown that the cerebral hemisphere opposite the dominant hand is most often the dominant hemisphere (Bryden, 1988). Accordingly, right-handers often exhibit left hemisphere dominance, which is concurrently the hemisphere where language is thought to be specialized (Bryden, 1988; Kimura, 1961). This theory highlights the most commonly accepted hypothesis regarding why dichotic listening is a challenge. Once an auditory stimulus is perceived, it can travel by an ipsilateral or a contralateral afferent pathway to the brain. Based on human and animal research, Kimura observed that the contralateral pathways are dominant and in the presence of competing stimuli, can override the ipsilateral paths. Therefore, stimuli presented to the right ear have an advantage.

Due to the superiority of the contralateral afferent pathways, signals from the right ear would reach the left hemisphere fastest and therefore get processed first. Signals from the left ear must travel through the right hemisphere and across the corpus callosum before receiving attention in the left hemisphere (Kimura 1967). Therefore, signals from the right ear reach the left hemisphere language center before signals from the left ear. This slight time delay requires memory activation to protect against forgetting the signal. These extra stresses on memory and attention are also proposed compounding factors implicating task difficulty that ultimately lead to the observed REA (Kinsbourne, 1970). This theory is significant in that it strives to explain the processes behind the REA as well as the difficulty of dichotic listening.

Several studies have noted that performance on dichotic listening tasks decreases significantly with increasing age (Carter & Wilson, 2001; Strouse et al., 2000; Strouse et al., 2000; Jerger, Oliver, & Pirozzolo, 1990). Specifically, these experiments have shown that recognition performance for older listeners is substantially compromised as compared to younger listeners. According to one study by Roup et al. (2006), young adult listeners with no hearing loss successfully recalled an average of 86.9% of the words presented to their right ear and 84.4% of words presented to their left ear. Therefore, in younger listeners, the REA was present yet relatively small at 2.5%. Comparatively, older listeners only recalled 48.3% in the right ear and 36.1% in the left ear, yielding a 12.2% difference between ears in older listeners. Both subject groups displayed REA’s, but the effects were more dramatic in older listeners. The Roup et al. study highlights the two unique performance differences between young and older listeners in a dichotic task. First, the percent correct scores for the younger listeners were better overall than the older listeners. Second, the REA was significantly larger in older listeners as compared to younger listeners. These findings are important in that they exemplify how older listeners lack proficiency in a difficult dichotic listening task.

Speech-in-Noise

During a speech-in-noise task, a subject is asked to attend to a speech signal that is at least partially masked by background noise. The subject then needs to focus attention on the intended signal and block out the undesired background noise. This signal may be a syllable, word or sentence. The competing sound may be white noise, filtered noise, a single speaker, multiple speakers, etc. Often, the intensity level of the signal and/or the noise is varied to determine at what level the noise must be presented to negatively impact the listener’s performance. Speech-in-noise tests have proven to be harder for older persons as compared to younger listeners, based on their frequent reduced performance (Gordon-Salant, 1986; Tun, Wingfield, & O’Kane, 2002; Souza & Turner, 1994).

In one study by Dubno, Dirks, and Morgan (1984) four subject groups were compared: two groups consisted of young adults and two groups consisted of older adults. Each age group was then divided into subjects with either normal hearing or sensorineural hearing loss (SNHL), yielding four groups. Dividing subjects in this manner allowed the researchers to determine if age, hearing loss, or both impacted performance on a speech-in-noise task. Dubno and colleagues found that understanding a speech signal in noise is determined by the level of hearing loss as well as a listener’s age. The listeners with SNHL exhibited poorer percent correct scores than listeners with no hearing loss and the older listeners consistently performed poorer than the young listeners. Also, when younger and older listeners with matching pure tone audiometric results were compared, the older listeners performed worse. The results of the study by Dubno et al. are relevant because they show that, similar to a dichotic listening task, older listeners consistently perform worse in speech-in-noise tasks than younger listeners, even after controlling for hearing loss. This demonstrates that older listeners lack proficiency on this difficult listening task.

Semantic content of the interfering noise also impacts a listener's ability to focus on the desired signal. Tun et al. (2002) described that when the desired speech signal was competing with another semantically meaningful sentence, adults exhibited lower signal recognition than when the competing message consisted of non-meaningful random word strings. Therefore, the background noise creates more interference if it is meaningful. This result was exaggerated in older listeners; older listeners are less able to focus on the desired signal when the competing noise(s) is meaningful. Older adults' reduced performance on speech-in-noise tasks are clinical manifestations of "real world" listening situations. When considering listening in a real-world setting, background chatter contains semantically relevant information. If a listener is located in a noisy restaurant, the background conversations will consist of meaningful phrases, not random word strings. Therefore, listening in a noisy restaurant is a difficult listening situation, especially for older listeners.

Auditory Declines with Aging

Numerous studies have shown that older adult listeners perform worse, exhibiting consistently lower percent correct recognition scores, on dichotic listening

(Carter & Wilson, 2001; Roup et al., 2006) and speech-in-noise tasks (Barrenas & Wikstrom, 2000; Dubno et al., 1984; Yilmaz et al., 2007) as compared to younger adult listeners. Along with overall reduced performance, older adults demonstrated several unique patterns dependent upon stimulus type. In one dichotic listening study, Carter and Wilson (2001) examined the effects of lexical differences of dichotic stimuli between younger and older listeners. After dividing stimuli into “easy” and “hard” words, they found that younger listeners were able to identify all words better overall than their older counterparts. The older listeners were able to report significantly more “easy” than “hard” words. This shows that older listeners struggle more during a difficult listening tasks, especially when the desired speech signal is less often used in daily speech and therefore is harder to predict. Another interesting trend was observed in this study. The younger listeners did not exhibit a significant ear effect. In contrast, older listeners were better able to identify words presented to the right ear, regardless of lexical difficulty, showing a significant REA. This evidence further strengthens the observed exaggerated REAs in older listeners, showing that aging is associated with auditory declines in difficult listening situations.

Roup et al. (2006) evaluated the effect of age on dichotic word recognition. Once again, older listeners showed significantly larger REAs (12.3-15.3%) than younger listeners. The younger listeners approached maximum performance so the REA was negligible. It is interesting to note that younger listeners were able to approach maximum performance, while older listeners were not. This is yet another example of the negative impact of age on auditory capabilities; older listeners were less proficient than younger listeners in a difficult listening situation.

An experiment by Yilmaz et al. (2007) found evidence to support that speech-in-noise performance declines with age. Subjects in this study all had normal hearing based on pure tone audiometry results, so hearing loss was not a compounding factor. Speech-in-noise performance began to significantly decline after age 40 and continued to decline with increases in age. Specifically, Yilmaz and colleagues noted that speech-in-noise performance was relatively stable until age 40, when it started to decline. Subjects in their 40's showed minimal reductions in performance. Subjects in their 50's showed consistent declines. The results were significantly worse in subjects in their 60's. The researchers pointed out that the average subject in their 60's performed 37% worse on the speech-in-noise task than the average subjects in their 40's. These results provide more evidence to support that performance on difficult listening tasks is reduced for older adult listeners.

Another unique trend in older listeners is the tendency to misunderstand a spoken signal but believe or respond as if they understood it correctly. Gordon-Salant (1986) utilized the theory of signal detection to explain this phenomenon. Gordon-Salant noted that "elderly listeners are relatively conservative in committing themselves to a signal response for externally controlled events but are relatively confident in the accuracy of their own responses" (p. 161). In this experiment, listeners had to identify a stimulus, and then judge the accuracy of their response. Older listeners were slower to identify the stimulus, but once they did they reported higher confidence scores than younger listeners. This may suggest that older listeners are guessing at responses in their daily lives, so they are more familiar with this type of listening scenario than younger listeners. The familiarity causes them to be overconfident in their ability to discriminate a difficult stimulus.

All of these results are evidence supporting common anecdotal claims that perception declines with age. Multiple theories have been proposed regarding the cause behind these auditory declines. Barrenas and Wikstrom (2000) theorized that high frequency SNHL is the main factor that affects an older listener's ability to perceive and discriminate speech signals. Another theory proposed that declines in memory and cognition are responsible for the struggles of older listeners (Kinsbourne, 1970). The third popular theory suggests that declines in interhemispheric function, mainly the degradation of signal transmission across the corpus collosum are responsible for the auditory trends observed in older listeners (Bellis & Wilber, 2001). While one theory has yet to be unanimously proven, the evidence for auditory processing declines with age are evident.

Test Anxiety

Test anxiety is defined as a situation-specific trait that includes both anxious states and worrisome cognitions (Schwarzer & Jerusalem, 1992). Similarly, Hembree (1988) categorizes two components of test anxiety, worry and emotionality. Worry refers to the apprehension a person feels when thinking about his or her own performance. Emotionality encompasses the physiological reactions that are stimulated by those worrisome thoughts, such as perspiration and an accelerated heart rate. Furthermore, the level of test anxiety experienced by a participant is associated with task difficulty and participant proficiency. A specific cause of test anxiety has yet to be pinpointed, but several proposed theories exist.

One theory suggests that these emotional and physiological responses to testing situations interfere with the subject's available mental capacities for attention, therefore, performance is negatively impacted (Pekrun 1992). Simply, worry hinders a test taker's ability to focus on the task at hand. Another theory, reviewed by Jones and Petruzzi (1995) claims that poor organizational and study skills are solely to blame for poor test results. The last and most widely accepted theory, also reviewed by Jones and Petruzzi, is the social learning model. This model emphasizes the importance of self-efficacy and of a locus of control; these phenomena can be looked at as a task-dependent continuum. When a subject has experience on a given test matter, his or her self-efficacy rating tends to be higher than if they were to attempt an unfamiliar task. According to this theory, subjects who lack proficiency in a certain task have low self-efficacy and therefore, are less likely to perform well on the specified task. Difficult listening assessments, such as dichotic listening and speech-in-noise are unfamiliar tasks to the average listener; the listener lacks proficiency. Utilizing the social learning model, dichotic listening and speech-in-noise tasks could be anxiety inducing due to lacking self-efficacy and task proficiency.

Schwarzer (1992) reported evidence to support the theory that older populations are more likely to experience anxiety as they suffer from age-related losses in physical, cognitive, and environmental aptitudes. These losses lead to a declined sense of self-efficacy in regards to coping with stressful situations. Anxiety has also been shown to contribute to the incidence of elderly depression and withdrawal from social situations. Weinstein and Ventry (1982) revealed strong correlations between state anxiety and social isolation in the elderly. Depression and isolation are often linked to suicide in the elderly.

Little research has been published regarding test anxiety in a clinical setting or in elderly populations. With social isolation and increased rates of depression linked to anxiety in older populations, clinical test anxiety needs to be addressed in elderly populations.

One study, by Roup and Chiasson (2010) reported that dichotic listening caused a significant increase in self-reported anxiety in young adult listeners. The subjects were inexperienced with dichotic listening. The study examined whether subjects reported increased levels of anxiety overall, and whether the difficulty of the stimulus affected the level of anxiety based on the State Trait Anxiety Inventory (STAI). During the dichotic testing session, anxiety levels rose significantly. For example, from pre-test to post-CVs, there was an average increase of 8.21 points on the STAI scale. In contrast, there was no significant difference reported between stimulus types. This suggests that dichotic listening is difficult overall, regardless of stimulus type. No such study has been performed regarding older adults.

Benyon, Clarke and Baguley (1995) examined the effects of patient comfort during various audiological tasks. This study did not focus on anxiety, but patient discomfort could be preceded by apprehension that may trigger anxiety. From a clinical standpoint, a provider needs to be aware of both their patient’s comfort and anxiety levels. Anxiety can negatively impact performance; during a clinical diagnostic procedure, an overly anxious patient may not perform to their ability and exhibit biased results. An invalid test result impedes the clinician’s ability to best help the patient.

Purpose

Hembree (1988) noted that levels of anxiety are directly related to task difficulty and participant proficiency. Based on performance in the experiments cited previously, dichotic listening and speech-in-noise are two difficult auditory tasks. These tasks are hypothesized to be especially difficult for older listeners due to this high difficulty level and unfamiliarity with the tasks. Anecdotal evidence regarding the difficulty of these tasks can be found in noisy restaurants environments, where older adults often describe struggling to understand their conversational partners. Many older persons report that these day to day tasks are difficult, sometimes so difficult that they choose not to attend possibly problematic events at all. Weinsten and Ventry (1982) also noted that this self-sought social isolation leads to depression and a decreased quality of life. Therefore, the secondary purpose of this research is to determine if elevated state-anxiety levels negatively impact a person's self-reported quality of life.

The effects of difficult listening tasks on state anxiety have not been tested in older populations. Based on the results reported by Roup and Chiasson (2010), dichotic listening is an anxiety inducing task for young listeners. A similar experiment utilizing speech-in-noise testing could not be located. The result of speech recognition tests, specifically dichotic performance and speech recognition in noise, on state anxiety in elderly listeners is unknown and is the focus of this research. The primary purpose of this research is to determine whether speech recognition tasks (speech recognition in noise and dichotic listening) will affect self-reports of state anxiety in older listeners. It is hypothesized that the speech recognition tasks will cause an increase in state-anxiety.

To test the hypothesis, a group of young adult listeners and a group of older adult listeners were tested. The young adult listeners served as a control for the data collected from the older adult listeners. Each group underwent the same procedure consisting of an initial hearing screening to determine eligibility and cognitive awareness, a selected set of speech-recognition-in-noise and dichotic listening tasks, and each participant was asked to fill out the state-trait anxiety inventory between each task. Participants were also asked to report if they ever experience difficulty in real life listening situations. If they responded “yes,” they were asked to describe the difficulties they face and if these difficulties ever affect their participation in social interactions.

Chapter 2
Methods

Subjects

Twenty participants were recruited from The Ohio State University (OSU), OSU Speech-Language and Hearing Clinic, and the surrounding area of Franklin County. The subjects were divided into two groups: young adults with normal hearing and older adults with SNHL. The young adults ranged from 20-23 years of age (8 female, 2 male). The older adults ranged from 63-82 years of age (4 female, 6 male). Subjects had normal otoscopy (no blockage, drainage, etc.) and tympanometry results (Roup et al., 1998; Wiley et al., 1997). Subjects were required to have symmetric hearing (no more than a $\pm$ 10 dB interaural difference in air conduction thresholds at 500-4000 Hz). For the young adult group, normal hearing was defined as thresholds $\leq$ 20 dB HL at 250-8000 Hz. For the older adult group, hearing loss was limited to those with a mild SNHL hearing loss at 500 Hz (40 dB HL) and no more than a moderately- severe SNHL at 4000 Hz (70 dB HL). No assistive listening devices were worn during testing. Subjects were native speakers of English with no recent otic diseases. In addition, subjects were right handed as determined by questionnaire to minimize the variability of dichotic listening results often presented by left handed listeners (see Appendix A). The cognitive status of older adult subjects was verified by a score $\geq$ 25 on the Mini Mental State Examination (Folstein, 1975; see Appendix B). Subjects were compensated for their participation.

Materials

The present study used three clinical tests to assess subjects' ability to recognize speech stimuli presented in noise: 1) the Speech in Noise (SPIN) test (Bilger et al., 1984); 2) the Quick Speech Perception in Noise (QSIN) test (Killion et al., 2004); and 3) the Words in Noise (WIN) test (Wilson, Abrams & Pillion, 2003). The SPIN test assesses sentence recognition against multitalker babble and the subject was instructed to repeat the final key word of the sentence. There were two conditions: high and low predictability. Half of the sentences were high predictability; sentence context assisted the listener in predicting the final word of the sentence ('He would stir his coffee with a spoon'). Half of the sentences were low predictability; there was little context embedded within the sentence to help the listener predict the key word ('Bob called Tom about the strips'). The sentences are presented at a +8 signal to noise ratio (SNR). The QSIN test also assesses sentence recognition against multitalker babble. In a QSIN test, the subject repeated the entire sentence and five key words were scored. Thirty key words were scored per list (six sentences per list). The sentences were initially presented at a +25 dB SNR and decreased by 5 dB each time a sentence was presented. The results from a QSIN test are based on determining the listener's threshold. The threshold was defined as the SNR at which the participant recognizes 50% of the key words correctly. The final speech recognition task utilized was the WIN. The WIN test assesses monosyllabic word recognition against multitalker babble. A test list contains 7 words, and the subject repeats the word presented after the carrier phrase 'say the word'. The first sentence was presented at a +24 SNR and decreased by 4 dB each time a word was presented. The results from the WIN were also based on the listener's recognition threshold: the SNR at which the listener is 50% correct.

The Dichotic Digits Test was used to measure dichotic speech recognition (Strouse & Wilson, 1999). This test stimuli consisted of up to three pairs of dichotic digits presented in succession from the Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0. Each pair consisted of the digits 1-10 except 7. Seven is multisyllabic and therefore excluded from the possibilities. Subjects repeated every digit they heard from a list of 54 items with the one-, two-, and three- pair digit possibilities. Free recall was allowed so subjects repeated every digit they heard without presentation order as a priority. The results from the Dichotic Digits Test were reported as a percent correct (the number of stimuli repeated correctly).

The S-anxiety subscale of the State-Trait anxiety inventory (STAI, Form Y-1; Spielberger, 1983) was used to assess state anxiety correlated with the speech recognition testing. The S-anxiety subscale asked subjects to answer to what degree 20 statements encompasses how they felt in that moment. The 20 statements were a mix of positive ('I feel relaxed') and negative ('I feel anxious') items. Subjects use a 4-point Likert scale (1 = not at all; 2 = somewhat; 3 = moderately so; 4 = very much so) to rate the degree that each statement encompasses how they feet at that moment. Scores range from 20 (lowest level of state anxiety) to 80 (highest possible level of state anxiety).

<u>Procedures</u>

After each subject met the required criteria, a 1-2 hour session was scheduled for the experiment. To determine a baseline anxiety level, each subject completed an anxiety questionnaire before beginning the speech recognition testing. Subjects underwent each of the four speech recognition tasks (SPIN, QSIN, WIN and Dichotic Digits) in a single test session. The order of presentation of the four tests was counterbalanced across subjects. Subjects were familiarized with each test procedure prior to administration to guarantee understanding of the procedure. In addition to the baseline anxiety assessment, the subjects were asked to fill out the anxiety questionnaire after completing each speech recognition task.

Experimental testing occurred in a sound proof booth (IAC, Model 403ATR). The speech recognition tests were routed through a CD player (Sony CE375) to the audiometer (Grason Stadler, Model 61). Signals were presented to the subjects via insert ear phones. All young adult subjects received the stimuli at 50 dB HL. To guarantee audibility, the signals were presented to the older adults at at 30 dB SL above each subject’s threshold at 2000 Hz.

Chapter 3
Results

Speech Recognition Performance

Table 1 presents the mean scores and standard deviations of the young and older adult groups for each of the four speech recognition measures. As expected, the older adult group performed consistently poorer than the young adult group and exhibited a greater range of scores.

Poorer performance exhibited by the older adult group was evident when examining the speech-in-noise scores of the two groups. On the SPIN test, young adults averaged 91.8 percent correct, whereas, the older adult group averaged 64.4 percent correct. On the QSIN test, the average threshold of the young adult group was 0.6 dB SNR, whereas the older adult group exhibited a 9.5 dB SNR average threshold,. On the WIN test, young adults exhibited a 6.4 dB SNR average threshold, whereas the older adults exhibited a 13.7 dB SNR mean threshold. A similar pattern was shown in the competitive listening task, dichotic digits. Young adults exhibited an average REA of 3.2 percent. This effect was exaggerated in older adults, as they exhibited a mean REA of 10.5 percent.

State Anxiety and Speech Recognition

Figure 1 presents mean STAI scores for the four speech recognition measures. As can be seen in Figure 1, state anxiety increased from baseline to each of the four tests in both groups. A two-way analysis of variance (ANOVA) with *group* as the between subjects variable and *test type* as the within subjects variable revealed no significant difference for *group* ($F_{1, 18} = .076$; $p > .05$). Therefore, there were no differences in self-reported state anxiety (STAI scores) between the young and older

Table 1. Means and standard deviations (in percent correct) for the four speech recognition measures for young and older adult groups.

	Young Adult Group	Older Adult Group
SPIN		
Mean (%)	**91.8**	**64.4**
St Dev	**2.9**	**14.1**
QSIN		
Mean dB SNR	**0.6**	**9.5**
St Dev	**1.2**	**4.5**
WIN		
Mean dB SNR	**6.4**	**13.7**
St Dev	**1.2**	**3.9**
Digits		
Mean EA(%)	**3.2**	**10.5**
St Dev	**11.4**	**14.1**

EA = ear advantage

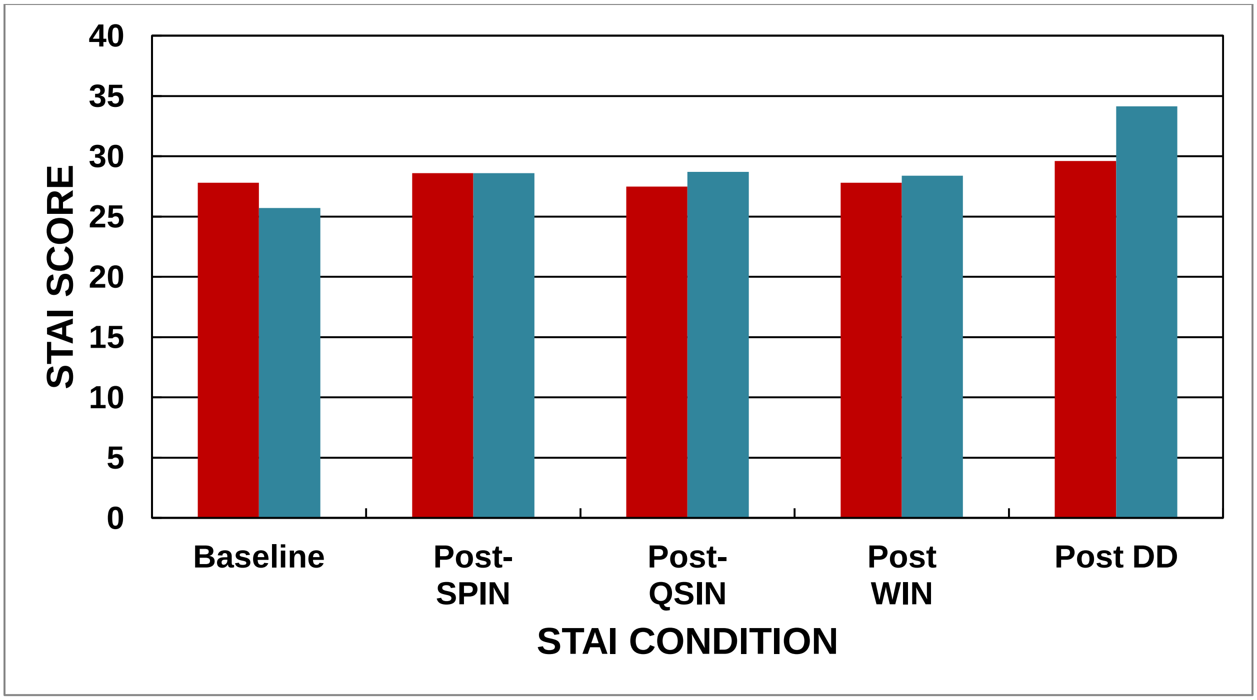

Figure 1. Mean STAI scores for young (red bars) and older adult (blue bars) groups across conditions (baseline, post-SPIN, post-QSIN, post-WIN, and post-Dichotic Digits).

adult groups. In contrast, results revealed a significant main effect for *test type* ($F_4 = 3.4$; $p < .05$). Post hoc analysis on the effect of *test type* on state anxiety using paired samples *t-tests* failed to reveal significant differences between baseline state anxiety and any test type for the young adult group. In contrast, post hoc paired samples *t-tests* revealed a significant difference between the baseline and post-dichotic digits STAI scores for the older adult group. Specifically, state anxiety was significantly greater post-dichotic digits than at baseline for the older adult group.

Figure 2 (A-D) presents individual STAI scores as a bivariate plot with baseline STAI scores on the abscissa and the post-test STAI scores on the ordinate for each of the four speech recognition tests. STAI scores below the diagonal line indicate greater state anxiety before speech recognition testing, and scores above the diagonal line indicate greater state anxiety after speech recognition testing. Scores on the diagonal line indicate no change in state anxiety as a function of speech recognition testing. As can be seen in each of the four plots, there was a great deal of variability within the results; therefore, no general trends are observable in the data with the exception of the dichotic digit data. Specifically, Figure 2D clearly illustrates that the majority of subjects in both groups experienced an increase in state anxiety related to dichotic digit recognition testing.

Performance and Anxiety

Changes in state anxiety for each condition type are presented in Figure 3. Specifically, STAI difference scores were calculated between baseline and each speech recognition test and presented as boxplots. The boxplots demonstrate the range of change in state anxiety across groups for each test condition. Each boxplot includes

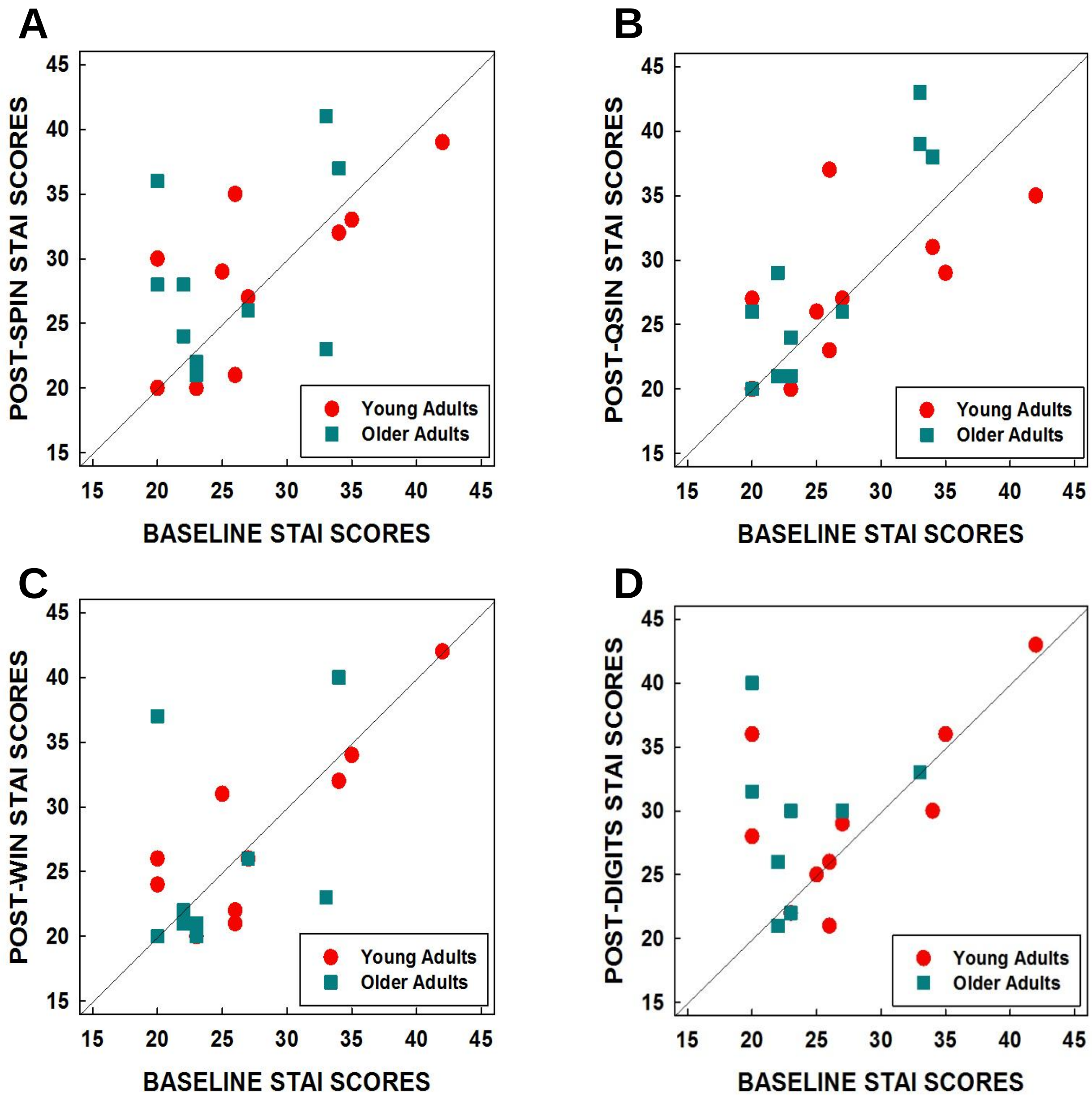

Figure 2. Individual data presented as bivariate plots of baseline STAI score (abscissa) and post-speech recognition STAI score (ordinate): post-SPIN (panel A), post-QSIN (panel B), post-WIN (panel C), and post-DIGITS (panel D).

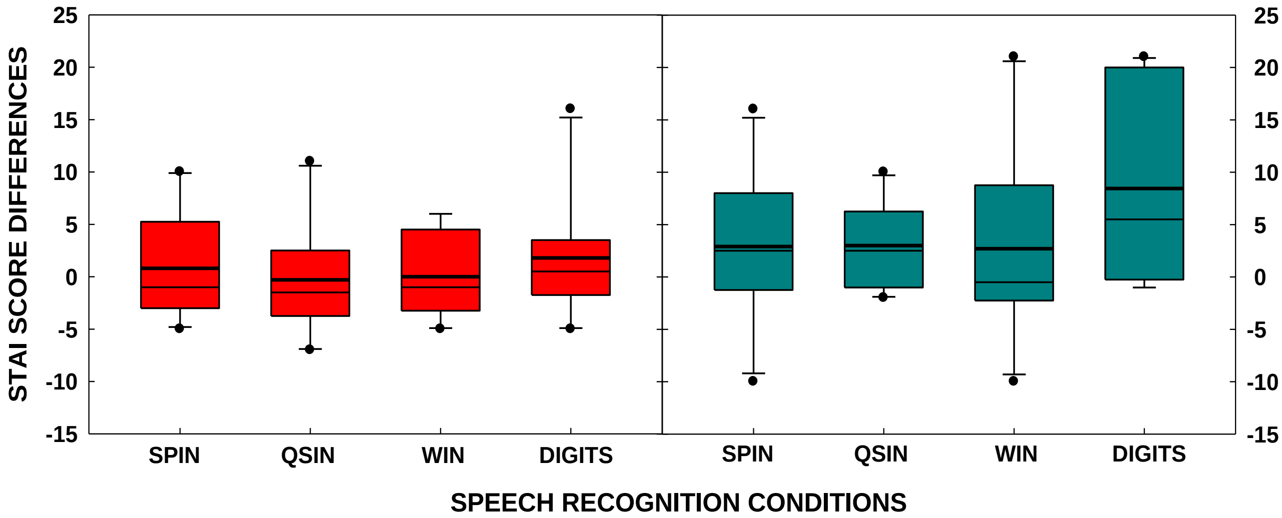

Figure 3. Mean difference STAI scores presented as box plots for young (red) and older adult (blue) groups across conditions (SPIN, QSIN, WIN, and Dichotic Digits). Each boxplot includes the: median (thin black line), mean (thick black line), 25th and 75th percentiles (lower and upper box), 10th and 90th percentiles (whiskers), and outliers (dots).

**Difference STAI scores were calculated by taking subtracting the baseline STAI score from each of the post-test STAI scores.*

the median (thin black line), mean (thick black line), 25th and 75th percentiles (lower and upper box), 10th and 90th percentiles (whiskers) and outliers (dots). As can be seen in Figure 3, the older adult group is more variable in their anxiety levels than the young adult group as demonstrated by the greater range of STAI difference scores. However, no significant correlations between recognition performance and state anxiety were found at the group level.

In order to determine if increases in state anxiety impacted speech recognition performance at the individual level, outliers identified in Figure 3 (dots) were examined in greater detail. The individual data for the subjects exhibiting the greatest increase in state anxiety (i.e., outliers) are presented in Table 2. Examination of the individual data revealed that three young adults and two older adults exhibited abnormal ($\geq$ the 90th percentile) increases in state anxiety. Overall, each of these five participants performed at average or above average on at least two of the four speech recognition measures. With the exception of one ear advantage score (noted on Table 2), none of these subjects' performances fell below one standard deviation from the mean. It was noted that three out of the five subjects exhibited abnormal STAI score increases after the dichotic digit presentation.

After examining the overall performance of the five subjects with abnormal STAI score increases, performance relative to the specific speech recognition test that preceded the abnormal increase in state anxiety was also looked at. Young adult subject #2 exhibited an above average threshold on the QSIN measure before reporting an abnormal STAI score increase. Likewise, older adult subject #10 exhibited an abnormal STAI score increase after performing average or better on both the SPIN and dichotic test conditions. In contrast, young adult subject #4 exhibited an abnormal STAI score increase after a SPIN performance that was merely 1.8% below the young adult average. Interestingly, young adult subject #10's STAI score was elevated after the dichotic presentation. This subject exhibited a *left* ear advantage of 3.7% compared to the average young adult group's *right* ear advantage of 3.2%. Therefore, this subject's ear advantage was similar in magnitude to the group average, but with better performance in the opposite ear. The final outlier subject, older adult subject #1 showed unique results. This subject exhibited abnormal STAI score increases after three speech recognition measures. Specifically, above average thresholds on the QSIN and WIN preceded abnormal STAI score increases. This subject's other elevated STAI score followed a dichotic performance that fell more than one standard deviation below the average. To summarize, five subjects yielded eight abnormal STAI score increases. Of the eight abnormal STAI score increases, five were directly related to an average or above average speech recognition performance.

Table 2. Individual data from those subjects with abnormally high increases in STAI scores (≥ the 90th percentile; highlighted in red). Data presented in blue was the only recognition score that fell ≥1 standard deviation from the group mean.

	SPIN % Correct	QSIN dB SNR	WIN dB SNR	Digits % Ear Advantage
Young Adult Group				
Subject #2				
Performance	98%	0	5.6	-13%
STAI Increase	9	**11**	-4	-5
Subject #4				
Performance	90	1.5	6.8	-3.7
STAI Increase	**10**	7	6	8
Subject #10				
Performance	92	-1	4.4	-3.7
STAI Increase	0	0	4	**16**
Older Adult Group				
Subject #1				
Performance	80	3	7.2	**-7.4**
STAI Increase	8	**10**	**21**	**20**
Subject #10				
Performance	64	8.5	14.8	5.5
STAI Increase	**16**	6	17	**20**

Chapter 4
Discussion

The purpose of the present study was to determine if speech recognition testing was related to increases in self-reported state anxiety in young and older adults. This study also looked at whether performance on those speech recognition measures correlated with changes in state anxiety after each test condition.

For the *between groups* comparisons, results revealed that older adults performed poorer overall than younger adults across all speech recognition measures. Based on previous research, the performance difference between age groups was expected (Barrenas & Wikstrom, 2000; Roup, Wiley, & Wilson, 2006; Yilmaz, Sennaroglu, Sennaroglu, & Kose, 2007). Results also revealed that no significant differences between young and older adults existed in the self-reported STAI scores. The lack of difference in state anxiety between groups likely indicates that increased age and SNHL are not factors that affect state anxiety.

In contrast, a significant increase in state anxiety was found for the older adult group in the post-digit condition. Previous research by Roup and Chiasson (2011) also showed an increase in state anxiety post-dichotic presentations. Since task difficulty and participant proficiency are correlated with anxiety, the increased anxiety due to the dichotic presentation in older adults supported the idea that dichotic presentations are difficult listening tasks. The lack of increased state anxiety across the speech-in-noise tasks suggests that those standardized measures are not as difficult as a dichotic presentation.

It was thought that increases in state anxiety would correlate with reduced recognition performance, but the results did not support this hypothesis. At the group level, there was no correlation between state anxiety and performance. After further analysis of those subjects with the greatest increases in state anxiety (outliers from Figure 3), it was determined that, in a few of those individuals, abnormally large increases in state anxiety were measured after an average or above average performance on a speech recognition test. While this trend did not support the original hypothesis, interpretation of these findings is not implausible. It is most often thought that state anxiety negatively correlates with task performance; however, the reverse effect has also been observed (Hembree, 1988). State anxiety can have a beneficial and facilitative effect on test performance. This seems to have been the case for those subjects who performed average or better on a speech recognition measure and still exhibited an abnormal increase in state anxiety. Increased state anxiety may have heightened their attention and desire to do well on the test, yielding an average or above average performance on an unfamiliar task. Therefore, it must be noted that increases in state anxiety are not always detrimental.

The minimal significant effects found in the present study could be a reflection of intrinsic drawbacks of laboratory research. First, the messages presented to subjects were in a controlled setting. The recognition of the stimuli did not have a profound effect on the patient's day-to-day functioning. In a real-life setting, however, many older subjects reported frustration at not being able to understand spoken messages, especially in the presence of background noise. While most subjects claimed not to avoid noisy situations, the reported frustration mirrors an increase in anxiety outside of a laboratory setting. An audiologic patient in an evaluation is more likely to foresee acute consequences of his or her performance outcomes than a participant in the present study. In addition, it is possible that research participation attracts a specific type of volunteer. In a clinical setting, patients are referred or seek treatment to improve their quality of life. Many research participants are outgoing and looking for an interesting, educational afternoon; they sought out the “procedure.” This outgoing volunteer may be less affected by anxiety than a clinical patient, or a person who is less likely to seek out a volunteering opportunity. These factors must be kept in mind when comparing these speech recognition tests to audiologic evaluations.

Clinical Implications and Further Research

The speech-in-noise measures utilized in the present study are often used to clinically diagnose patients’ speech recognition abilities. It is necessary to determine if patient performance on these tests may be impacted by anxiety. Awareness of patient anxiety is beneficial for more than counseling purposes. If performance results are detrimentally impacted, the patient’s true abilities may not be reflected. To reduce the variability reported in the present study, a larger sample group should be tested to see if trends can be pinpointed.

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References

Barrenas, M.L. & Wikstrom, I. (2000). The influence of hearing and age on speech recognition scores in noise in audiological patients and in the general population. *Ear & hearing,* 21: 569-577.

Bellis, T.J., & Wilber, L.A., (2001). Effects of aging and gender on interhemispheric function. *J Speech Hear Res.* 44:246-263.

Beynon, G.J., Clarke, N., & Baguley, D.M. (1995). Patient comfort in audiological testing. *Br J Audiol, 29*:1-5.

Bilger, R., Nuezel, J., Rabinowitz, W., & Rzeczkowski, C. (1984). Standardization of a test of speech perception in noise. *J Speech Hear Res*, *27*:32-48.

Broadbent, D.E. (1954). The role of auditory localization in attention and memory span. *J Exp Psychol, 47*:191-196.

Bryden, M. (1988). An overview of the dichotic listening procedure and its relation to cerebral organization. In K. Hugdahl (Ed.), Handbook of Dichotic Listening: Theory, methods and research. New York: Wiley.

Carter, A.S., & Wilson, R.H. (2001). Lexical effects on dichotic word recognition in young and elderly listeners. *J Am Acad Audiol*m 12: 86-100.

Dubno, J.R., Dirks, D.D., & Morgan, D.E. (1984). Effects of age and mild hearing loss on speech recognition in noise. *J Acoust Soc Am*, 76(1) 87-96.

Folstein, MF et al. (1975). “Mini-Mental State”: A practical method for grading the cognitive status of patients for the clinician. *J Psych Res* 12:167-173.

Gordon-Salant, S. (1986). Effects of aging on response criteria in speech-recognition tasks. *J Speech Hear Res,* 29: 155-162.

Harris, K.C., Dubno, J.R., Keren, N.I., Ahlstrom, J.B., & Eckert, M.A. (2009). Speech recognition in younger and older adults: a dependency on low-level auditory cortex. *J Neuro,* 29(19): 6078-6087.

Hembree, R. (1988). Correlates, causes, effects, and treatment of test anxiety. *Rev Educ Res*, *58*:7-77.

Humes, L.E. (1996). Speech understanding in the elderly. *J Am Acad Audiol*, 7: 161-167.

Humes, L.E., Dubno, J.R., Gordon-Salant, S., Lister, J.L., Cacace, A.T., Cruikshanks, K.J., Gates, G.A., Wilson, R.H., & Wingfield, A. (2012). Central presbycusis; a review and evaluation of the evidence. *J Am Acad Audiol*, 23: 635-666.

Jerger, J., Oliver, T., & Pirozzolo, F. (1990). Impact of central auditory processing disorder and cognitive deficit on the self-assessment of hearing handicap in the elderly. *J Am Acad Audiol, 1*:75-80.

Jones, L. & Petruzzi, D. C. (1995). Test Anxiety: a review of theory and current treatment. *J College Student Psychotherapy,* 10(1): 3-15.

Killion, M.C., Niquette, P.A., Gudmundsen, G.I., Revit, L.J., & Banerjee, S. (2004). Development of a quick speech-in-noise test for measuring signal-to-noise ratio loss in normal hearing and hearing-impaired listeners. *J Acoust Soc Am*, *116*(4):2395-2405.

Kimura, D. (1961). Cerebral dominance and the perception of verbal stimuli. *Can J Psychol, 15*(3):166-171.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. *Cortex*, 3(2):163-178.

Kinsbourne, M. (1970). The cerebral basis of lateral asymmetries in attention. *Acta Psychologica*, 33:193-201.

Kramer, S.E., Kapteyn, T.S., & Festen, J.M. (1998). The self-reported handicapping effect of hearing disabilities. *Audiology*, *37*:302-312.

Noffsinger, D., Martinez, C.D., & Wilson, R.H. (1994). Dichotic listening to speech: background and preliminary data for digits, sentences, and nonsense syllables. *Journal of the American Academy of Audiology*, 5:248-254.

Noffsinger, D., Martinez, C.D., & Andrews, M. (1996). Dichotic listening to speech: VA-CD data from elderly subjects. *J Am Acad Audiol, 7*:49-56.

Pekrun, R. (1992). The impact of emotions on learing and achievement: Towards a theory of cognitive/motivational mediators. *Applied Psychology*, 41(4): 359-376.

Roup, C.M., & Chiasson, K.E. (2010). Effect of dichotic listening on self-reported state anxiety. *Int J Audiol, 49*:88-94.

Roup, C.M., Wiley, T.L., & Wilson, R.H. (2006). Dichotic word recognition in young and older adults. *J Am Acad Audiol*, 17: 230-240.

Schwarzer, R. (1992). Anxiety in the elderly. In H. van der Ploeg, R. Schwarzer, & C. Spielberger (Eds.), *Advances in Test Anxiety Research*. Lisse, The Netherlands: Swets & Zeitlinger.

Schwarzer, R., & Jerusalem, M. (1992). Advances in anxiety theory: a cognitive process approach. In H. van der Ploeg, R. Schwarzer, & C. Spielberger (Eds.), *Advances in Test Anxiety Research*. Lisse, The Netherlands: Swets & Zeitlinger.

Souza P.E., & Turner C.W. (1994). Masking of speech in young and elderly listeners with hearing loss. *J Speech Hear Res.* 37: 655-661.

Spielberger C.D. (1983). Manual for the State-Trait Anxiety Inventory (Form Y-1). Palo Alto, USA: Consulting Psychologists Press.

Strouse, A., & Wilson, R.H. (1999). Recognition of one-, two-, and three-pair dichotic digits under free and directed recall. *J Am Acad Audiol, 10*:557-571.

Strouse, A, Wilson, R., & Brush., N. (2000a). Effect of order bias on the recognition of dichotic digits in young and elderly listeners. *Audiology*, 39: 93-101.

Strouse., A, Wilson, R., & Brush., N. (2000b). Recognition of dichotic digits under pre-cued and post-cued response conditions in young and elderly listeners. *Br J Audiol,* 34: 141-151.

Strouse Carter, A., & Wilson, R.H. (2001). Lexical effects on dichotic word recognition in young and elderly listeners. *J Am Acad Audiol*, 12: 86-100.

Tun, P.A., Wingfield, A., & O'Kane, G. (2002). Distraction by competing speech in young and older adult listeners. *Psychology and Aging,* 17(3): 453-467.

Weinstein, B.E., & Ventry, I.M. (1982). Hearing impairment and social isolation in the elderly. *J Speech Hear Res, 25*:593-599.

Wilson, R.H., & Leigh, E.D. (1996). Identification performance by right- and left-handed listeners on dichotic CV material. *J Am Acad Audiol*, 7: 1-6.

Wilson, R.H., Abrams, H.B., & Pillion, A.L. (2003). A word-recognition task in multitalker babble using a descending presentation mode from 24 dB to 0 dB signal to babble. *J Rehabil Res Dev, 40*(4):321-328.

Yilmaz, S.T., Sennaroglu, G., Sennaroglu, L., & Kose, S.K. (2007). Effect of age on speech recognition in noise and on contralateral transient evoked otoacoustic emission suppression. *J Laryngology & Otology*, 121: 1029-1034.

Yueh, B., Shapiro, N., MacLean, C.H., & Shekelle, P.G. (2003). Screening and management of adult hearing loss in primary care. *JAMA,* 289(15): 1976-1985.

Appendix A

Edinburgh Handedness Inventory

Please indicate your preferences in the use of hands in the following activities *by putting a check in the appropriate column.* Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, *put 2 checks.* If in any case you are really indifferent, *put a check in both columns.*

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	☐ ☐	☐ ☐
2. Drawing	☐ ☐	☐ ☐
3. Throwing	☐ ☐	☐ ☐
4. Scissors	☐ ☐	☐ ☐
5. Toothbrush	☐ ☐	☐ ☐
6. Knife (without fork)	☐ ☐	☐ ☐
7. Spoon	☐ ☐	☐ ☐
8. Broom (upper hand)	☐ ☐	☐ ☐
9. Striking Match (match)	☐ ☐	☐ ☐
10. Opening box (lid)	☐ ☐	☐ ☐
TOTAL(count checks in both columns)		

Difference	Cumulative TOTAL	Result
/	*100 =	

Scoring:
Add up the number of checks in the "Left" and "Right" columns and enter in the "TOTAL" row for each column. Add the left total and the right total and enter in the "Cumulative TOTAL" cell. Subtract the left total from the right total and enter in the "Difference" cell. Divide the "Difference" cell by the "Cumulative TOTAL" cell (round to 2 digits if necessary) and multiply by 100; enter the result in the "Result" cell.

Interpretation (based on Result):

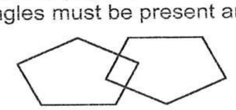
- below -40 = left-handed
- between -40 and +40 = ambidextrous
- above +40 = right-handed

Appendix B

Mini-Mental State Examination (MMSE)

Patient's Name: ______________________________ Date: ____________

Instructions: Score one point for each correct response within each question or activity.

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day? Month?"
5		"Where are we now? State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then the instructor asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible.
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, …) Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.) 
30		TOTAL